**Non-$CO_2$ Greenhouse Gas Emissions Data for Climate Change Economic Analysis***

by

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GTAP Working Paper No. 43
2008

*Chapter 5 of the forthcoming book *Economic Analysis of Land Use in Global Climate Change Policy*, edited by Thomas W. Hertel, Steven Rose, and Richard S.J. Tol

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*Steven K. Rose and Huey-Lin Lee*

## 1. Introduction

Non-$CO_2$ (carbon dioxide) greenhouse gas emissions (NCGGs) are responsible for almost a third of historic radiative forcing, and land related activities contribute approximately two thirds of global NCGG emissions. Therefore, modeling of NCGG emissions is essential for projecting climate change and evaluating the net environmental effectiveness of alternative climate change mitigation strategies.

This chapter describes the GTAP NCGG emissions dataset. It highlights NCGG emissions associated with land-based activities, and the heterogeneity of sectoral and regional NCGG emissions. The NCGG dataset complements the GTAP fossil fuel combustion $CO_2$ emissions database (Lee, 2005) and the forest carbon stock dataset, where the later is described in chapter 2[1] of this volume. Together, the datasets provide a fairly complete GHG emissions and carbon sink profile for each sector within each region.

The GTAP NCGG emissions data were derived from new highly disaggregated country-level emissions source data from the United States Environmental Protection Agency (USEPA) (Rose et al., 2007b). Unlike other NCGG databases, the data was specifically developed for direct integration with economic activity datasets. The detailed USEPA source emissions data and the explicit linking of NCGG emissions directly to

[1] GTAP Working Paper No. 40

emissions drivers (e.g., energy use, land use, fertilizer, capital) during the mapping to the GTAP economic activity dataset, allows for more explicit, realistic, and internally consistent modeling of emissions activity and mitigation technologies and costs. The NCGG dataset was collaboratively developed by USEPA and Purdue University's Global Trade Analysis Project (GTAP). The most current version of the dataset is publicly available on the GTAP website (https://www.gtap.agecon.purdue.edu/).

## 2. Background

NCGGs include nitrous oxide ($N_2O$), methane ($CH_4$), and fourteen fluorinated gases (F-gases) (Table 1).[2] These greenhouse gases (GHGs), along with carbon dioxide, are referred to as the Kyoto basket of greenhouse gases. Like $CO_2$, NCGGs are gases that trap heat in the Earth's atmosphere. They trap more heat per molecule than $CO_2$. NCGGs were responsible for 30% of radiative forcing between pre-industrial times and 1990 (IPCC, 2001). USEPA (2006a) projects NCGG growth of 44% from 1990 to 2020, with methane two thirds of 1990 emissions and growing by 35%, and nitrous oxide just under a third of 1990 emissions growing by 41%, while the F-gases in total represent approximately 3% of 1990 emissions growing by almost 300% to become 7% of NCGG emissions by 2020.[3]

[2] In the database, the fourteen F-gases are grouped into four representative groups: $CF_4$ (Perfluoromethane), HFC-134a (Hydrofluorocarbons, $C_2H_2F_4$), HFC-23 (Hydrofluorocarbons, $CHF_3$), $SF_6$ (Sulphur hexafluoride).

[3] Based on carbon dioxide equivalent units computed using the IPCC Second Assessment Report 100-year global warming potentials for reporting inventories (IPCC, 1996).

**Table 1. Non- $CO_2$ greenhouse gases included in the database and their 100-year global warming potential (GWP) (IPCC, 1996)**

| Gas | GWP |
|---|---|
| Carbon dioxide ($CO_2$) | 1 |
| Methane ($CH_4$) | 21 |
| Nitrous oxide ($N_2O$) | 310 |
| HFC-23 | 11,700 |
| HFC-32 | 650 |
| HFC-125 | 2,800 |
| HFC-134a | 1,300 |
| HFC-143a | 3,800 |
| HFC-152a | 140 |
| HFC-227ea | 2,900 |
| HFC-236fa | 6,300 |
| HFC-4310mee | 1,300 |
| $CF_4$ | 6,500 |
| $C_2F_6$ | 9,200 |
| $C_4F_{10}$ | 7,000 |
| $C_6F_{16}$ | 7,400 |
| $SF_6$ | 23,900 |

Land use and land based practices represent an important driver of NCGG emissions. In 2000, agricultural land related activities were estimated to produce approximately 50% of global atmospheric methane ($CH_4$) emissions and 75% of global nitrous oxide ($N_2O$) emissions. This amounts to a total contribution to all anthropogenic greenhouse gas emissions in 2000 of approximately 14% on a carbon dioxide equivalent basis (USEPA, 2006a). By tying NCGG emissions directly to economic activities, as is done with the dataset described in this chapter, we have an explicit characterization of emissions associated with economic sectors and an economic structure for modeling NCGG emissions. In Figure 1 and Table 2, we see that land related economic sectors are responsible for 60% of global NCGG emissions, with ruminant livestock production contributing the largest share at 25%, and paddy rice second at 8%, followed closely by various crops and non-ruminant livestock.

**Figure 1. 2001 global land-use related shares of NCGG emissions**

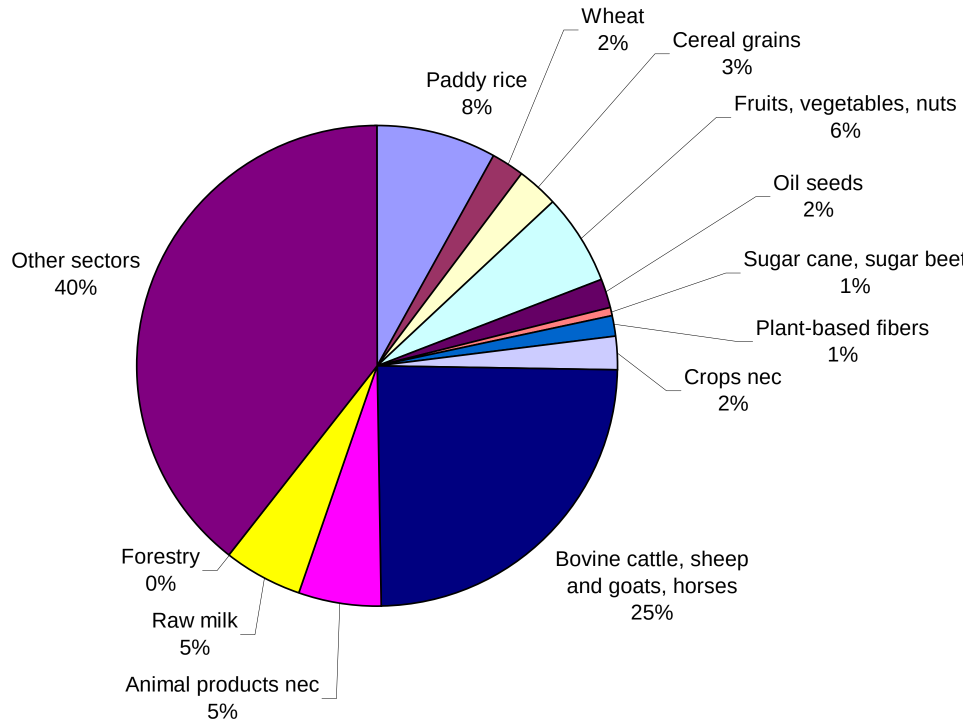


**Table 2. 2001 global land-use related NCGG emissions**

| Sector | MtCeq |
|---|---|
| Paddy rice | 199 |
| Wheat | 57 |
| Cereal grains | 67 |
| Fruits, vegetables, nuts | 150 |
| Oil seeds | 49 |
| Sugar cane, sugar beet | 18 |
| Plant-based fibers | 31 |
| Crops nec | 55 |
| Bovine cattle, sheep and goats, horses | 609 |
| Animal products nec | 136 |
| Raw milk | 133 |
| Forestry | 0 |
| ***TOTAL land-use related sectors*** | ***1505*** |
| ***Other sectors*** | ***976*** |

NCGGs are important because of both their historic and projected contributions to radiative forcing and climate change, as well as for their climate change mitigation potential, especially as alternatives to fossil fuel combustion $CO_2$ emissions mitigation. Previous engineering-based studies and project experience through government programs has identified a variety of viable NCGG mitigation technologies and provided estimates of direct project net costs (e.g., USEPA, 2006b). Furthermore, macroeconomic studies have found that NCGG mitigation opportunities offer mitigation flexibility that could lower the costs of achieving emissions reduction quantity objectives, such as for national commitments, cap-and-trade programs, and long-run climate change stabilization (e.g., de la Chesnaye and Weyant, 2006). In addition, Rose et al. (2007a) reports results explicitly isolating potential cost-effective roles for land-based NCGG mitigation, as well as forest sequestration and bioenergy, in dynamic climate change stabilization mitigation portfolios. Meanwhile, public-private partnerships have identified and developed profitable NCGG reduction partnerships (e.g., USEPA's Methane to Markets program, http://www.epa.gov/methanetomarkets/). Research results and hands-on experience like these have justified the inclusion of NCGG mitigation alternatives in international programs such as the UNFCCC Joint Implementation and Clean Development Mechanism Programs, as well as their explicit inclusion in recently proposed U.S. legislation.

Despite all this, sector-level and economy-wide NCGG emissions and mitigation modeling is still relatively unsophisticated. In large part, because modelers have focused their efforts on modeling energy and industrial fossil fuel $CO_2$ emissions based on fuel combustion (Hourcade et al., 2001). As that modeling has advanced and global NCGG emissions and cost data have become available, the modeling community has shifted its attention to the other categories of emissions—NCGGs, non-combustion $CO_2$, and land-use and land-use change $CO_2$. The initial modeling, built off aggregated databases and aggregated and partially integrated representations of mitigation responses, established that NCGG mitigation could be a substantial part of a cost-effective strategy (de la Chesnaye and Weyant, 2006). However, more explicit evaluation of NCGG mitigation technologies and the impact of NCGG mitigation decisions within and across sectors and regions calls for more disaggregated consistent emissions source data that is integrated more directly with the economic activity generating the emissions.

The GTAP NCGG database was developed to fill this need and facilitate more refined modeling and evaluation of NCGG emissions and mitigation potential. For each region, the dataset provides disaggregated source-level NCGG emissions for each economic sector and regional household. Furthermore, the sector emissions are tied to emissions drivers: factor inputs (endowments), intermediate inputs, or output. Household emissions are tied to intermediate input use, specifically energy use. The NCGG emissions are reported in terms of the 87 GTAP regions, 57 sectors, and regional households associated with version 6 of the GTAP database.

The NCGG database is one part of a GTAP/EPA development effort designed to improve international climate modeling by developing key climate related datasets that are both internally consistent and integrated with core economic activity datasets. A number of complementary resources are currently available, some products of the GTAP/EPA project, including GTAP datasets for fossil fuel combustion $CO_2$ emissions, land-use and land-cover, forest carbon; and USEPA datasets for country-level historical and near-term NCGG projections, and NCGG emissions abatement costs estimates. See Rose et al. (2007c) for an overview of these resources. Furthermore, development efforts are on-going that will yield additional GTAP/EPA products and improvements in the future. Additional data products will include a global soil carbon dataset and, as discussed below, incorporation of additional emissions categories, including non-fossil fuel combustion $CO_2$ emissions, as well as additional biomass burning and biomass combustion $CO_2$ and non-$CO_2$ emissions.

The remainder of this chapter is organized as follows. The next section describes the methodologies employed in developing the GTAP NCGG dataset. The remaining sections provide an overview of the data and discuss modeling opportunities. Land-based NCGG emissions are emphasized throughout.

## 3. Methodology

This section describes the NCGG input data for the GTAP NCGG dataset and the methods employed in mapping the data. Each NCGG emissions source (subcategory) from the input data set for each country was allocated to the corresponding GTAP sector(s) or regional household and then directly to an appropriate unique economic activity emissions driver within each sector/household. This methodology ensures that GTAP NCGG emissions totals are consistent with the original sources, while emissions-driver relationships are customized to the economic model structure.

### *3.1 USEPA NCGG emissions input data*

The US Environmental Protection Agency (USEPA) developed a detailed non-$CO_2$ and non-fossil fuel combustion $CO_2$ ("Other $CO_2$") greenhouse gas emissions database specifically for use by global economic models (Rose et al., 2007b). The dataset's disaggregated emissions structure maps directly to countries and economic sectors and facilitates utilization of available input activity quantity data, such as energy volumes and land-use acreage in both the mapping of emissions into GTAP as well as emissions modeling.

Other global emissions datasets have provided valuable regional and global estimates (e.g., USEPA, 2006a; Olivier, 2002); however, estimated emissions have been developed and presented according to IPCC source categories that aggregate across countries, and more importantly, aggregate across economic sectors and activities; thereby, making it difficult to model actual emitting activities and abatement strategies. The Rose et al. (2007b) NCGG emissions categories and subcategories are also based on

IPCC emissions inventory categories and subcategories (IPCC, 1997a); however, the data is substantially more disaggregated than other datasets. The 2001 base year of the new dataset corresponds to the base year of the GTAP version 6 database. The database provides emissions for 29 non-$CO_2$ and Other $CO_2$ GHG emissions categories with 153 unique emissions sources (subcategories) for 226 countries. The other datasets provide emissions for more aggregated regions and do not provide emissions by subcategories. Annex 1 country emissions were extracted from national UNFCCC Common Reporting Framework and National Inventory submissions. Non-Annex 1 country emissions were primarily drawn and, when possible, disaggregated from available National Inventories. When National Inventories were not available or specific emissions categories were not represented, other data sources and methods were called upon: the EDGAR 3.2 database by RIVM/TNO[4] (biomass burning, Other $CO_2$), ALGAS country reports;[5] or, estimated using IPCC inventory methods or extrapolated from 2000 estimates. See Rose et al. (2007b) for more detailed descriptions of the methods used in developing the data in each of the USEPA NCGG emissions subcategories.

### *3.2 Mapping USEPA NCGG data to GTAP*

Table 3 provides a summary of the emissions categories and subcategories represented in the GTAP NCGG dataset. Most, but not all, of the USEPA categories and subcategories were mapped into GTAP. Specifically, 24 categories and 119 subcategories

[4] EDGAR (Emission Database for Global Atmospheric Research), Version 3.2 (Olivier, 2002)
[5] ALGAS (Asia Least-Cost Greenhouse Gas Abatement Strategy)

were mapped into GTAP. The 5 USEPA NCGG emissions categories and 34 subcategories not currently mapped into GTAP include:

a. Specific biomass burning $N_2O$ and $CH_4$ emissions not uniquely attributable to anthropogenic activity (middle and high latitude forest fires, middle and high latitude grassland fires, indirect $N_2O$ from tropical forest fires, tropical forest fires).

b. Biomass burning tropical forest fire deforestation $N_2O$, $CH_4$, and $CO_2$ emissions. Currently omitted because the emissions are associated with land-use change, and the GTAP land-use database (Lee et al., 2005) does not provide land-use change data. Please note however that GTAP forest carbon stock data is available that is consistent with the GTAP forest inventory dataset (see the previous chapter[6]). This data will allow for modeling changes of forest carbon.

c. Biomass combustion $N_2O$, $CH_4$, and $CO_2$ emissions. Omitted from mapping because the GTAP energy database does not currently include biomass energy volumes.

d. Methane from underground storage and geothermal energy. Only one country reported emissions in each of these subcategories, and the emissions were modest: Latvia (underground storage emissions of 0.33 Gg), and New Zealand (geothermal emissions of 2.47 Gg).

e. Other $CO_2$ emissions not attributable to fossil fuel combustion. This includes fugitive and combustion $CO_2$ emissions from the chemical

[6] GTAP Working Paper No. 42

industry and metal production, fugitive $CO_2$ emissions from oil production/transmission/handling, and $CO_2$ emissions associated with cement production. The first of these three categories was omitted due to concerns about double counting with the GTAP $CO_2$ combustion emissions database. The second and third will be added to the GTAP emissions database in the future.

Overall, the omitted emissions subcategories will be added to the database in the future as methodologies are developed and activity data becomes available. The USEPA emissions data omitted from the GTAP mapping are described in Rose et al. (2007c) and can be obtained from USEPA (Rose et al., 2007b).

Each of the USEPA emissions subcategories was individually mapped to the GTAP version 6 database's region and sector structure (87 regions, 57 sectors), and regional households (Table 3). For each of the USEPA emissions subcategories, the relevant set of emitting GTAP sectors was identified from a careful matching of IPCC emissions source definitions and driver descriptions (IPCC, 1997a, 1997b, 2000, 2003) to the underlying United Nations Central Product Classification (CPC) and International Standard Industrial Classification (ISIC) definitions associated with the GTAP sectors (see Appendix A for the CPC and ISIC codes associated with the GTAP sectors).

Many USEPA emissions subcategories mapped directly to individual GTAP sectors for each country (Table 3). However, disaggregation methodologies were required for subcategories that mapped to multiple GTAP sectors and/or when there were multiple emitting activities (e.g,, $CH_4$ and $N_2O$ emissions from combustion of coal, natural gas, and oil in GTAP energy sectors col, oil, gas, p_c, ely, and gdt). Where possible, GTAP input activity data was exploited for subcategory emissions disaggregation across sectors in order to integrate the datasets, thereby providing greater consistency across datasets.

There were four cases where an USEPA emissions category/subcategory did not map directly to a GTAP sector or country. In each case, shares were developed, either sector shares or country shares.

- Case 1: Category/subcategory maps to multiple GTAP sectors and there is only one emitting activity
- Case 2: Category/subcategory maps to multiple GTAP sectors and there are multiple emitting activities
- Case 3: Category/subcategory maps to multiple GTAP sectors but emissions source is poorly defined – this case applies only to livestock related subcategory designations of "UNKNOWN."
- Case 4: Category/subcategory includes aggregated regional emissions for a few smaller emitting countries that could not be disaggregated – this case applies only to two USEPA emissions categories—agricultural soils and pasture, range, and paddock.

For cases 1 and 2, GTAP base year activity and IPCC emissions factor data are applied when available. If not available, other methods were employed, such as using GTAP production shares. See Rose et al. (2007c) for a complete description of the mapping methodologies and the specific mapping and disaggregation handling for each subcategory.

## Table 3. Mapping NCGG categories and subcategories to GTAP v6 sectors and emissions drivers

| Category | Subcategory | GHG | GTAP sector | Emissions driver(s) |
|---|---|---|---|---|
| | | | | |
| Adipic and Nitric Production | Adipic Acid Production | N2O | crp | Output |
| | Nitric Acid Production | N2O | crp | Output |
| Agricultural Soils | Crop soils only - pasture, range, paddock disaggregated into its own category (below) | N2O | pdr, wht, gro, v_f, osd, c_b, pfb, ocr | Input (crp) |
| Biomass Burning | Agricultural Waste Burning | CH4 & N2O | pdr, wht, gro, v_f, osd, c_b, pfb, ocr | Output |
| | Savannah and Shrubs Fires | CH4 & N2O | ctl | Endowment (land) |
| Fugitives from Coal Mining Activities | | CH4 | col | Output |
| Fugitives from Oil and Natural Gas Systems | Natural gas - distribution | CH4 | gdt | Output |
| | Natural gas - exploration | CH4 | gas | Output |
| | Natural Gas - flaring | CH4 | gas | Output |
| | Natural gas - leakage | CH4 | gdt | Output |
| | Natural gas - leakage at industrial plants and power stations | CH4 | gdt | Output |
| | Natural gas - leakage at residential and commercial sectors | CH4 | gdt | Output |
| | Natural gas - production/processing | CH4 | gas, gdt | Output |
| | Natural gas - transmission | CH4 | otp | Output |
| | Natural Gas - venting | CH4 | gas | Output |
| | Oil - distribution of products | CH4 | p_c | Output |
| | Oil - exploration | CH4 | oil | Output |
| | Oil - flaring | CH4 | oil | Output |
| | Oil - other | CH4 | oil | Output |
| | Oil - production | CH4 | oil | Output |
| | Oil - refining and storage | CH4 | p_c | Output |
| | Oil - transport | CH4 | otp | Output |
| | Oil - venting | CH4 | oil | Output |
| Human Sewage | | N2O | osg | Output |
| Landfilling of Solid Waste | | CH4 | osg | Output |
| Livestock Enteric Fermentation | BUFFALO | CH4 | ctl | Endowment (capital) |
| | CAMEL (includes reportings for camels, alpaca, llamas, and camelids) | CH4 | ctl | Endowment (capital) |
| | DAIRY_CATTLE | CH4 | rmk | Endowment (capital) |
| | GOAT | CH4 | ctl | Endowment (capital) |
| | HORSE | CH4 | ctl | Endowment (capital) |
| | MULE/ASS | CH4 | ctl | Endowment (capital) |
| | NON-DAIRY_CATTLE (includes reportings for non-dairy cattle, deer, and reindeer) | CH4 | ctl | Endowment (capital) |
| | OTHER (includes reportings for fur bearing animals, ostrich, emus, rabbits, and "other") | CH4 | oap | Endowment (capital) |
| | POULTRY (includes reportings for chickens, ducks, geese, turkeys, and "poultry") | CH4 | oap | Endowment (capital) |
| | SHEEP/LAMB | CH4 | ctl | Endowment (capital) |
| | SWINE | CH4 | oap | Endowment (capital) |
| | UNKNOWN (not specified in reporting) | CH4 | ctl, oap, rmk | Endowment (capital) |

| Category | Subcategory | GHG | GTAP sector | Emissions driver(s) |
|---|---|---|---|---|
| Livestock Manure Management | BUFFALO | CH4 & N2O | ctl | Endowment (capital) |
| | CAMEL (includes reportings for camels and camelids) | CH4 & N2O | ctl | Endowment (capital) |
| | DAIRY_CATTLE | CH4 & N2O | rmk | Endowment (capital) |
| | GOAT | CH4 & N2O | ctl | Endowment (capital) |
| | HORSE (includes reportings for horses and combined reportings that include horses/goats/asses/mules/rabbits( | CH4 & N2O | ctl | Endowment (capital) |
| | MULE/ASS | CH4 & N2O | ctl | Endowment (capital) |
| | NON-DAIRY_CATTLE (includes reportings for non-dairy cattle, 1 to 3 year cattle, fat calves. deer, and equidea) | CH4 & N2O | ctl | Endowment (capital) |
| | OTHER (includes reportings for fur bearing animals and rabbits) | N2O | oap | Endowment (capital) |
| | POULTRY (Includes reportings for chickens, boilers, hens, ducks, geese, turkeys, and "poultry") | CH4 & N2O | oap | Endowment (capital) |
| | SHEEP/LAMB | CH4 & N2O | ctl | Endowment (capital) |
| | SWINE (includes reportings for swine, pig, and sow) | CH4 & N2O | oap | Endowment (capital) |
| | UNKNOWN (not specified in reporting) | CH4 & N2O | ctl, oap, rmk | Endowment (capital) |
| Other Industrial Non-Agricultural Sources | Mineral production | CH4 | nmm | Output |
| | Chemical production | CH4 | crp | Output |
| | Chemical production | N2O | crp | Output |
| | Iron, steel, & ferroalloys production | CH4 | i_s | Output |
| | Iron, steel, & ferroalloys production | N2O | i_s | Output |
| | Aluminum & non-ferrous Production | CH4 | nfm | Output |
| | All metal production | CH4 | i_s, nfm | Output |
| | Other | CH4 | omf, ppp | Output |
| | Other | N2O | omf, ppp | Output |
| Pasture, Range, and Paddock | BUFFALO | N2O | ctl | Endowment (capital) |
| | DAIRY_CATTLE | N2O | rmk | Endowment (capital) |
| | GOAT (includes reportings for goats and combined reportings that include goats/horses/deer/buffalo/donkeys/mules/emus/alpaca/camels) | N2O | ctl | Endowment (capital) |
| | HORSE (includes reportings for horses and combined reportings that include horses/goats/asses/mules/rabbits) | N2O | ctl | Endowment (capital) |
| | MULE/ASS | N2O | ctl | Endowment (capital) |
| | NON-DAIRY_CATTLE (includes reportings for non-dairy cattle, 1 to 3 year cattle, fat calves. deer, and equidea) | N2O | ctl | Endowment (capital) |
| | OTHER (includes reportings for fur bearing animals and rabbits) | N2O | oap | Endowment (capital) |
| | POULTRY | N2O | oap | Endowment (capital) |
| | SHEEP/LAMB | N2O | ctl | Endowment (capital) |

| Category | Subcategory | GHG | GTAP sector | Emissions driver(s) |
|---|---|---|---|---|
| Rice Cultivation | | CH4 | pdr | Endowment (land) |
| Stationary and Mobile Combustion | Stationary Combustion: Energy Industries | CH4 & N2O | col, oil, gas, p_c, ely, gdt | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Stationary Combustion: Total Industry Sector | CH4 & N2O | omn, cmt, omt, vol, mil, pcr, sgr, ofd, b_t, tex, wap, lea, lum, ppp, crp, nmm, i_s, nfm, fmp, mvh, otn, ele, ome, omf, cns | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Mobile Combustion: Total Transport Sector | CH4 & N2O | otp, wtp, atp | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Stationary and Mobile Combustion: Agriculture | CH4 & N2O | Crop sectors 1-8, livestock sectors 9-12, forestry, fishing | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Stationary Combustion: Commercial and Public Services | CH4 & N2O | wtr, trd, cmn, ofi, isr, obs, ros, osg | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Stationary Combustion: Residential | CH4 & N2O | households | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| | Non-specified Other | CH4 & N2O | osg | Inputs (refined oil (ep_c), coal (ecol), natural gas (egdt)) |
| Wastewater Treatment | | CH4 | osg | Output |
| Aluminum Production | Aluminum Production | CF4 | nfm | Output |
| Electrical Transmission and Distribution | Electrical Transmission and Distribution | SF6 | ely | Output |
| HCFC-22 Production | HCFC-22 Production | HFC-23 | crp | Output |
| Magnesium Manufacturing | Magnesium Manufacturing | SF6 | nfm | Output |
| ODS Substitutes | Aerosols (MDI) | HFC-134a | crp | Output |
| | Aerosols (Non-MDI) | HFC-134a | crp | Output |
| | Fire Extinguishing | HFC-134a | crp | Output |
| | Foams | HFC-134a | crp | Output |
| | Refrigeration/AC | HFC-134a | ele | Output |
| | Solvents | HFC-134a | crp | Output |
| Semiconductor Production | Semiconductor Production | CF4 | ele | Output |

### *3.3 Mapping to GTAP emissions drivers*

Tying emissions as closely as possible to emissions drivers allows for a more refined representation of abatement technologies and responses. For instance, there are many NCGG emissions that are closely related to input use. Nitrous oxide emissions from fertilizer usage and methane emissions from livestock are two obvious examples. With emissions tied to particular inputs, inputs can be adjusted to manage emissions while production is maintained via input substitution. When it is difficult to tie emissions directly to input usage due to a lack of (a) input use data, (b) scientific understanding of emissions generation processes, or (c) econometric production cost estimates, emissions are tied to the aggregate output of the sector.

The detailed specification of the GTAP endowment, intermediate input ("Input"), or output driver for each subcategory is listed in the last column of Table 3. In most cases, all the emissions associated with a category were assigned to the same type of driver. For biomass burning emissions, the specific subcategories were assigned unique drivers. For stationary and mobile combustion emissions, emissions were disaggregated and tied to each of the fossil fuel combustion activities.

It is important for modelers to recognize that specific emissions generation processes are obscured by these aggregated emissions-driver relationships. For instance, manure emissions depend on, among other things, the number of animals and the manure management system. Variation in either element of production across regions is represented by differences in capital in the GTAP database. Base year regional differences in the combination of animal number and manure management will be captured in the relationship between emissions and capital. However, the relationship will change over time due to autonomous and policy-driven technological change. Modelers need to be mindful of dynamics in the emissions-driver relationships to avoid unrealistic growth in future emissions and to appropriately apply mitigation technologies. See Hertel et al. (2006) and chapter 6[7] in this volume, which utilize the GTAP NCGG emissions database and USEPA (2006b) mitigation cost data, to develop and apply an initial detailed NCGG mitigation modeling framework specifically for agricultural activities.

[7] GTAP Working Paper No. 44

## 4. NCGG Data Overview

This section provides a graphical overview of the GTAP NCGG emissions database. Below are a variety of figures that were selected to give the reader a feel for the structure of the emissions data and level of disaggregation. The first set of figures illustrates global NCGG emissions by sector, region, and gas (Figures 2-3). Figure 2 illustrates that by far the largest NCGG emitting economic activity globally is the production of ruminant livestock (e.g., non-dairy cattle, sheep, goats, and horses) which generates enteric methane emissions as well as manure methane and nitrous oxide emissions. The next largest emitting activity is the provision of public services, where methane and nitrous oxide emissions are generated from wastewater, human sewage, and landfill activities, as well as stationary fossil fuel combustion processes.

Figure 3 identifies the top NCGG emitting regions: China ("chn"), the United States ("usa"), India ("ind"), and Brazil ("bra"). As was true for sectors (Figure 2), the distribution of gases across regions varies significantly. Noticeably, F-gases are a relatively small part of the global carbon equivalent emissions and are concentrated in the relatively few countries responsible for the vast majority of electronics, metals, and chemicals production.

The second set of figures (Figures 4 and 5) delve deeper into the data, presenting the NCGG *subcategory* emissions for two illustrative regions—the United States and China. Here we see that the data suggests that NCGG emissions come from a larger set of sectors in the US economy than in the Chinese economy; the F-gases are much more prominent proportionally in the US economy (electronic equipment manufacturing in particular); while paddy rice, ruminant livestock, non-ruminant livestock, and coal production are more dominant emitting activities in the Chinese economy. Waste handling (wastewater, human sewage, and landfills) is a large NCGG emissions source in both economies. Fugitive $CH_4$ and stationary and mobile combustion $CH_4$ and $N_2O$ emissions, as well as dairy cattle $CH_4$ and $N_2O$ emissions are noticeable in the US data, and almost non-existent in the Chinese data.

Figure 6 illustrates an additional dimension of the dataset that ties sector-level emissions to emissions drivers. Specifically, Figure 6 presents the USA NCGG emissions by sector in terms of emissions driver groups—endowments, intermediate inputs, and output. For instance, the “otp” sector includes both land transportation as well as pipeline transmission activities. NCGG fossil fuel combustion related emissions are attributed to output, while fugitive methane emissions occurring during transmission of fuels over pipelines is associated to fuel input levels. In land related economic sectors, NCGG emissions are mapped primarily to inputs, such as intermediate inputs like fertilizer use, and endowments like livestock capital stock and acreage. To simplify Figure 6, the subcategory emissions in each sector were aggregated by emissions driver.

## 5. Conclusion

NCGG emissions are important factors in climate change and should be considered for proper evaluation of the net environmental effectiveness of climate change policies. Furthermore, NCGGs mitigation technologies can add “what” flexilibility to “when” and “where” mitigation flexibility in achieving climate change goals. As a result, analysts will want to consider the potential emissions and mitigation impacts of NCGGs in the design of cost-effective policies. The disaggregated globally consistent NCGG dataset presented in this chapter was designed to facilitate more sophisticated assessment of the climate change role and mitigation opportunities associated with NCGGs. With greater country and emissions source resolution, the data was directly integrated with economic activity and specific emissions drivers; thereby, providing a better characterization of differences in sectoral and regional NCGG profiles and allowing for more refined evaluation of heterogeneous regional and sectoral production and consumption responses.

**Figure 2. 2001 global NCGG emissions by sector and gas (MtCeq)**

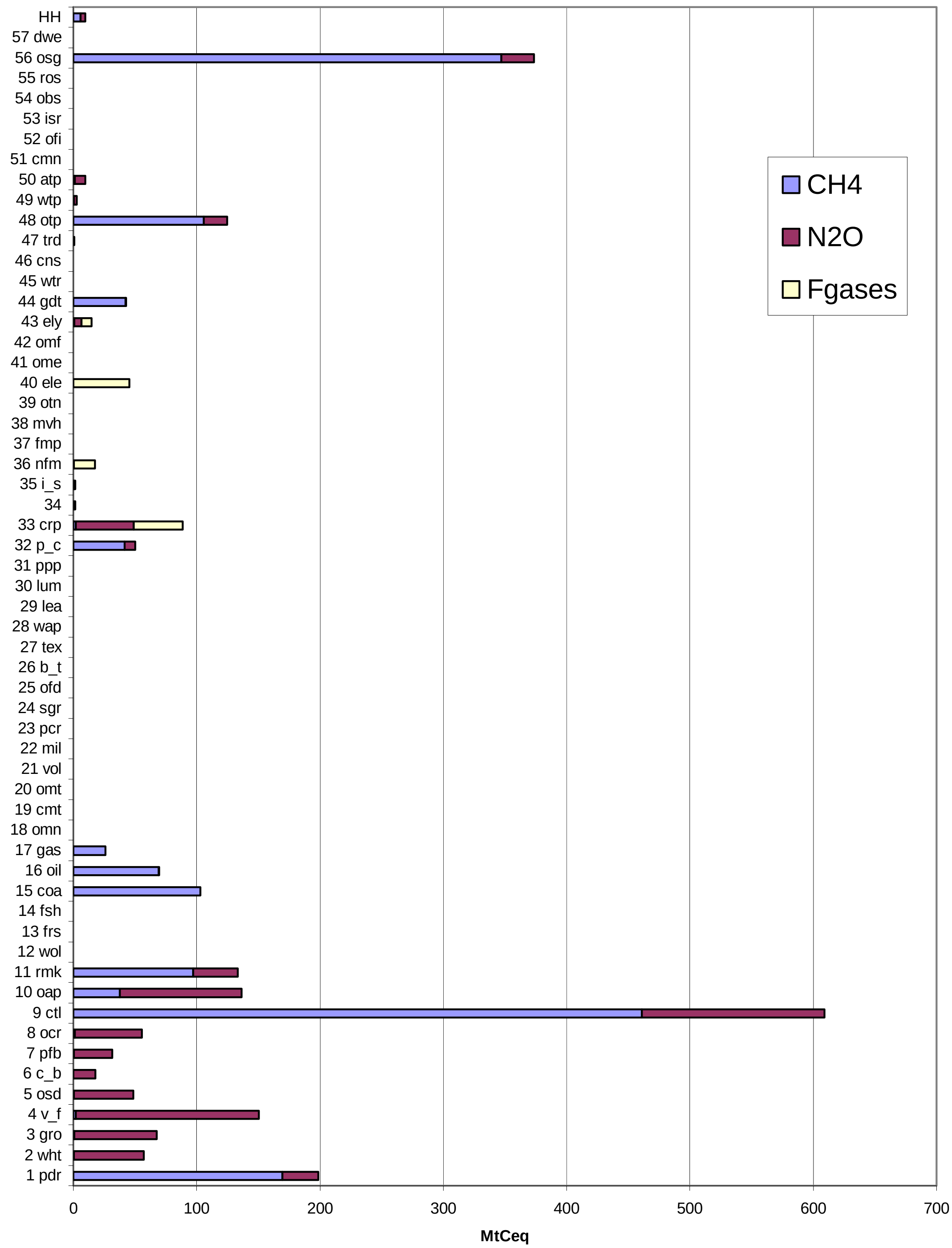


**Figure 3. 2001 global NCGG emissions by region and gas (MtCeq)**

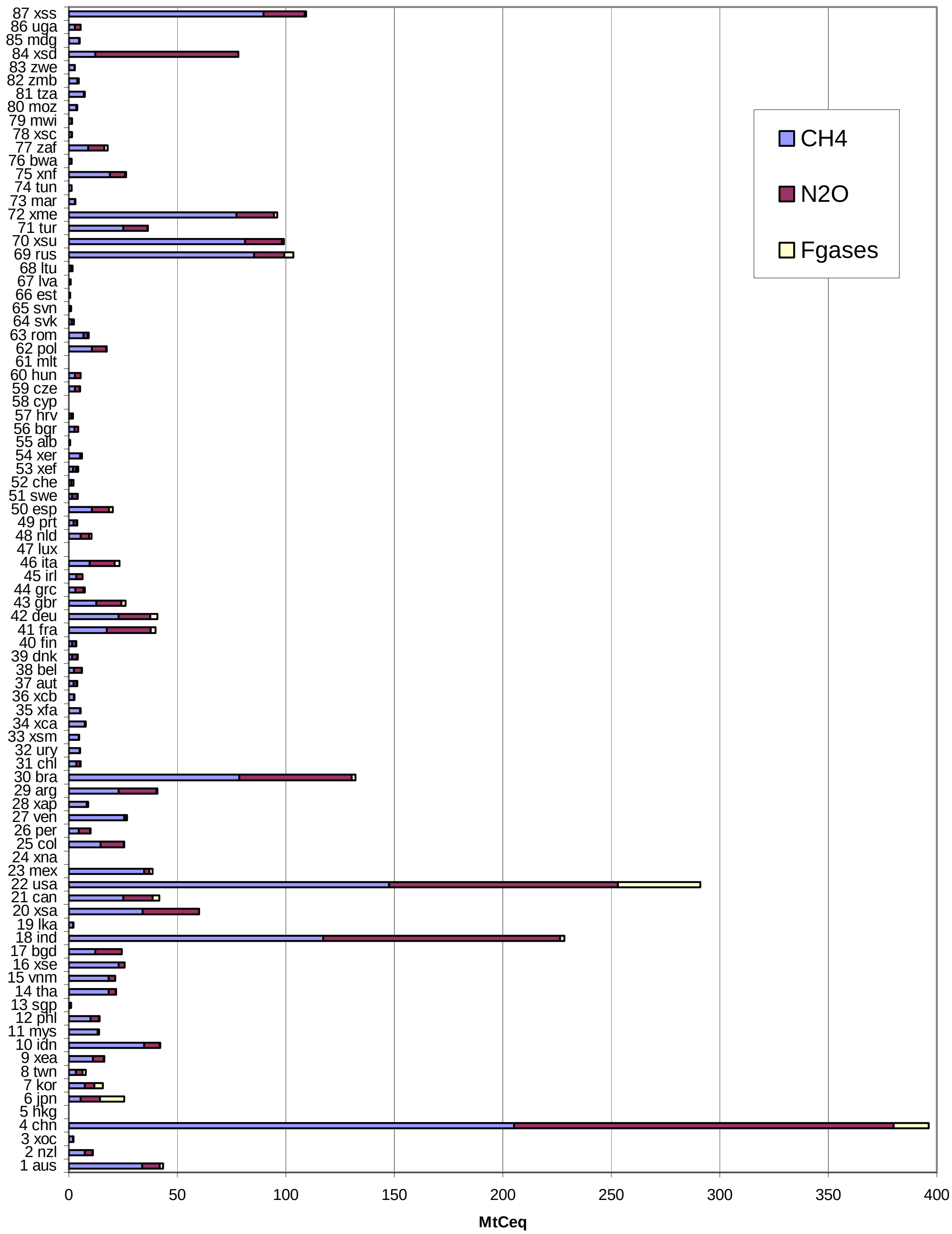


**Figure 4. 2001 United States NCGG emissions by sector and source (MtCeq)**

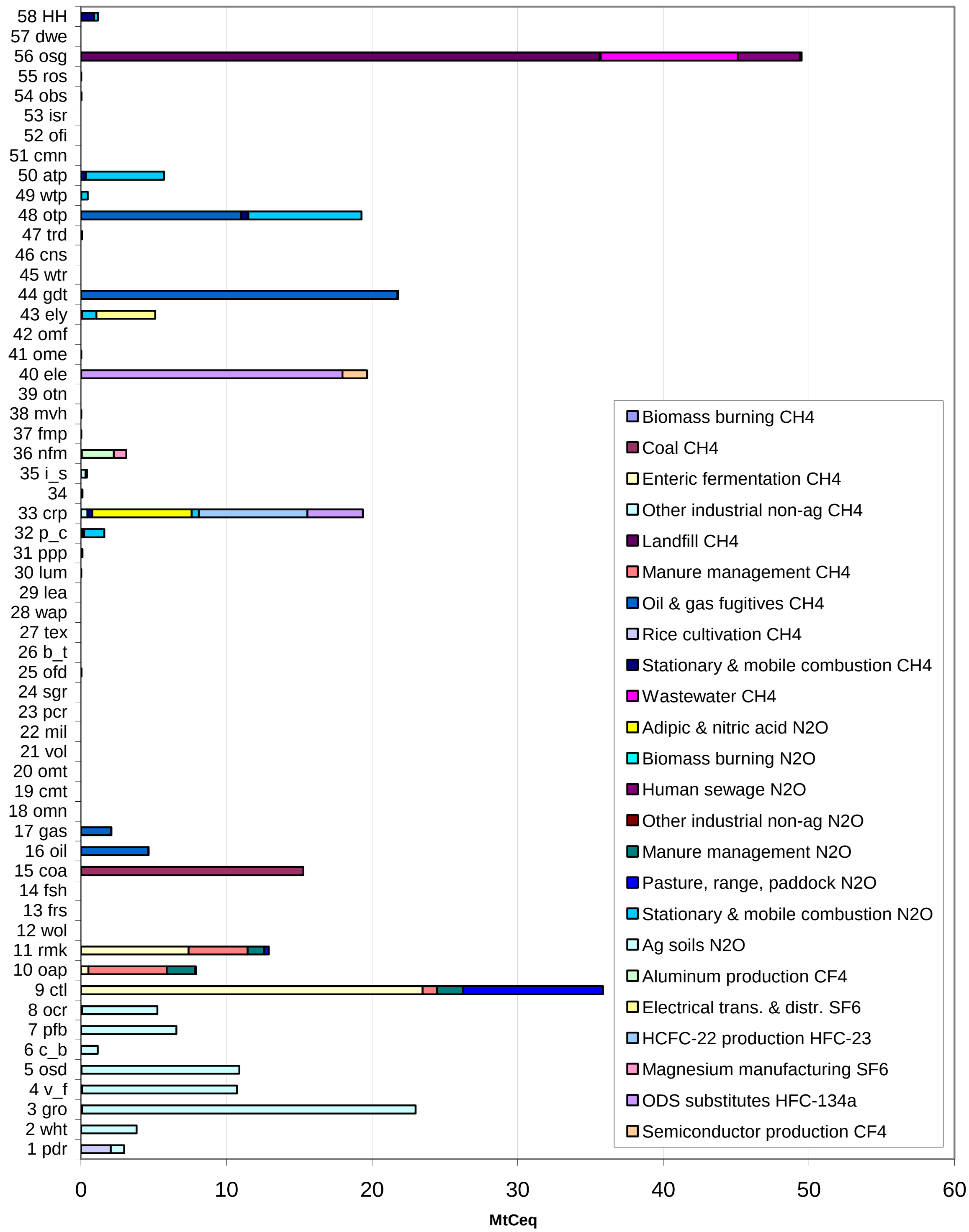


**Figure 5. 2001 China NCGG emissions by sector and source (MtCeq)**

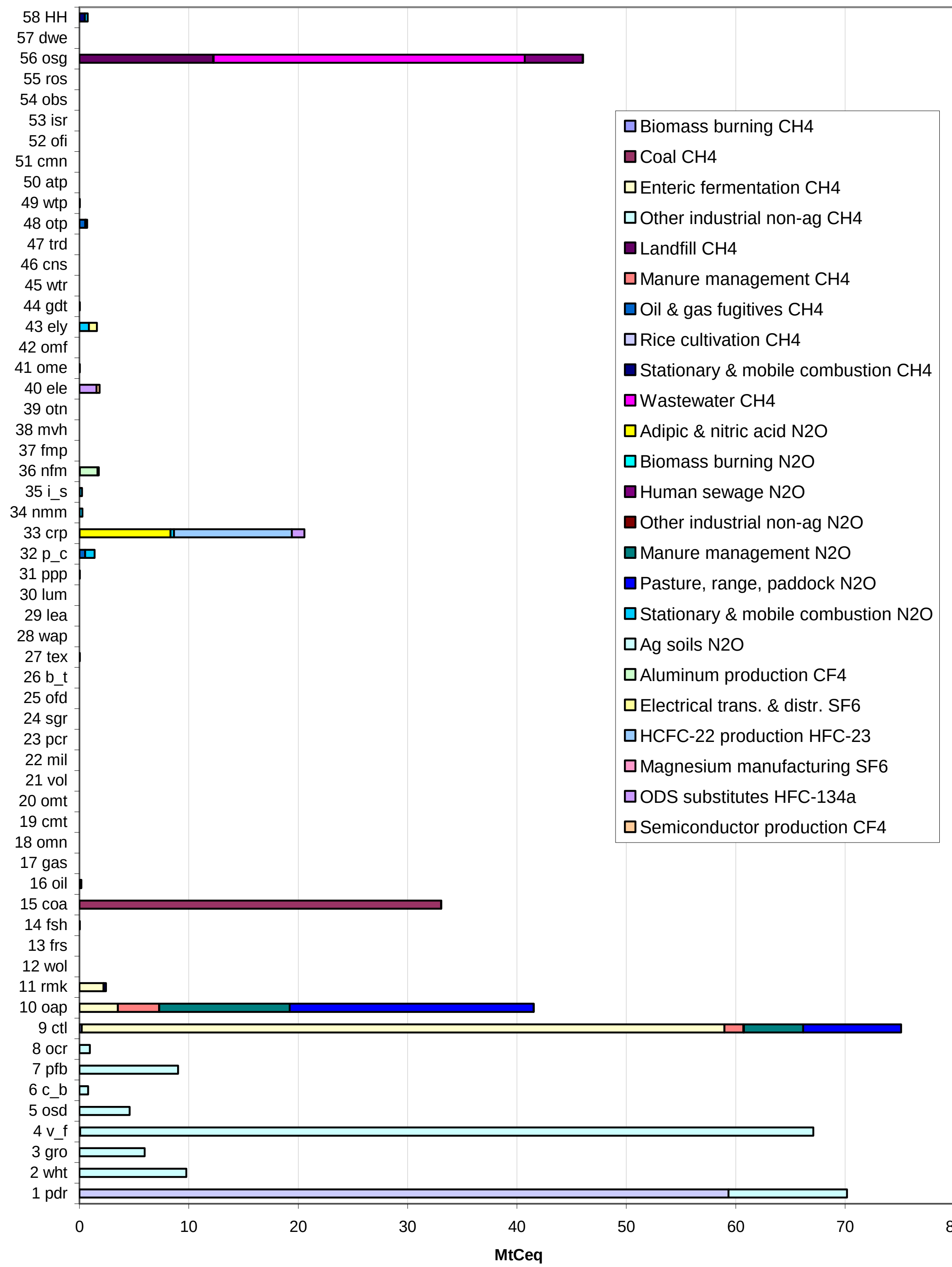
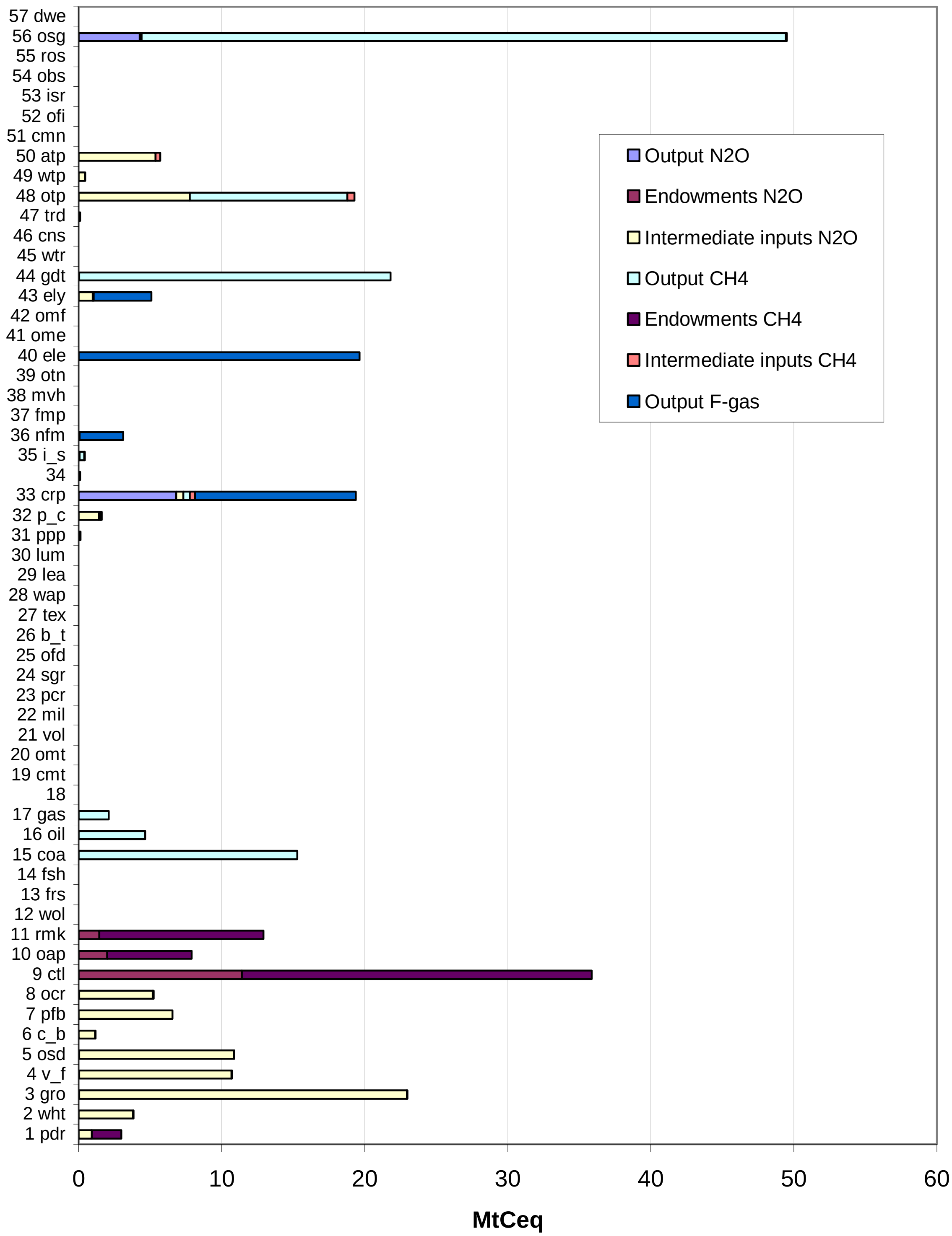


**Figure 6. 2001 United States NCGG emissions by sector and emissions driver type (MtCeq)**



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## Appendix A. GTAP sectoral classification

Source : GTAP database version 6 documentation
(https://www.gtap.agecon.purdue.edu/default.asp)

Tables A1 and A2 below show the sectoral definitions used in version 6.0 of the GTAP data base. The GTAP agricultural and food processing sectors are defined by reference to the Central Product Classification (*CPC*), as shown in table A1. The other GTAP sectors are defined by reference to the International Standard Industry Classification (*ISIC*), as shown in table A2. The ISIC is used for most sectors, because it is the reference point for sectoral classification in most I-O statistics. But for agriculture and food processing, the ISIC does not provide the detail GTAP needs, so CPC is used instead. The CPC was developed by the Statistical Office of the United Nations to serve as a bridge between the ISIC and other sectoral classifications (UN 1990, 1991).

Table A1. GSC2 Sectors defined by Reference to the Provisional CPC

| GSC2 Number | Code | CPC Code | Description |
|---|---|---|---|
| 1 | pdr | 0113<br>0114 | Rice, not husked<br>Husked rice |
| 2 | wht | 0111 | Wheat and meslin |
| 3 | gro | 0112<br>0115<br>0116<br>0119 | Maize (corn)<br>Barley<br>Rye, oats<br>Other cereals |
| 4 | v_f | 012<br>013 | Vegetables<br>Fruit and nuts |
| 5 | osd | 014 | Oil seeds and oleaginous fruit |
| 6 | c_b | 018 | Plants used for sugar manufacturing |
| 7 | pfb | 0192 | Raw vegetable materials used in textiles |
| 8 | ocr | 015<br>016<br>017<br>0191<br>0193<br>0194<br>0199 | Live plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds<br>Beverage and spice crops<br>Unmanufactured tobacco<br>Cereal straw and husks, unprepared, whether or not chopped, ground, pressed or in the form of pellets; swedes, mangolds, fodder roots, hay, lucerne (alfalfa), clover, sainfoin, forage kale, lupines, vetches and similar forage products, whether or not in the form of pellets<br>Plants and parts of plants used primarily in perfumery, in pharmacy, or for insecticidal, fungicidal or similar purposes<br>Sugar beet seed and seeds of forage plants<br>Other raw vegetable materials |
| 9 | ctl | 0211<br>0299 | Bovine cattle, sheep and goats, horses, asses, mules, and hinnies, live<br>Bovine semen |
| | | | Contd |

| GSC2 Number | Code | CPC Code | Description |
|---|---|---|---|
| 10 | oap | 0212 | Swine, poultry and other animals, live |
| | | 0292 | Eggs, in shell, fresh, preserved or cooked |
| | | 0293 | Natural honey |
| | | 0294 | Snails, live, fresh, chilled, frozen, dried, salted or in brine, except sea snails; frogs’ legs, fresh, chilled or frozen |
| | | 0295 | Edible products of animal origin n.e.c. |
| | | 0297 | Hides, skins and furskins, raw |
| | | 0298 | Insect waxes and spermaceti, whether or not refined or coloured |
| 11 | rmk | 0291 | Raw milk |
| 12 | wol | 0296 | Raw animal materials used in textile |
| 13 | for | 03 | Forestry, logging and related service activities |
| 19 | cmt | 21111 | Meat of bovine animals, fresh or chilled |
| | | 21112 | Meat of bovine animals, frozen |
| | | 21115 | Meat of sheep, fresh or chilled |
| | | 21116 | Meat of sheep, frozen |
| | | 21117 | Meat of goats, fresh, chilled or frozen |
| | | 21118 | Meat of horses, asses, mules or hinnies, fresh, chilled or frozen |
| | | 21119 | Edible offal of bovine animals, swine, sheep, goats, horses, asses, mules or hinnies, fresh, chilled or frozen |
| | | 2161 | Fats of bovine animals, sheep, goats, pigs and poultry, raw or rendered; wool grease |
| 20 | omt | 21113 | Meat of swine, fresh or chilled |
| | | 21114 | Meat of swine, frozen |
| | | 2112 | Meat and edible offal, fresh, chilled or frozen, n.e.c. |
| | | 2113 | Preserves and preparations of meat, meat offal or blood |
| | | 2114 | Flours, meals and pellets of meat or meat offal, inedible; greaves |
| | | 2162 | Animal oils and fats, crude and refined, except fats of bovine animals, sheep, goats, pigs and poultry |
| 21 | vol | 2163 | Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed rape, colza and mustard oil, crude |
| | | 2164 | Palm, coconut, palm kernel, babassu and linseed oil, crude |
| | | 2165 | Soya-bean, ground-nut, olive, sunflower-seed, safflower, cotton-seed, rape, colza and mustard oil and their fractions, refined but not chemically modified; other oils obtained solely from olives and sesame oil, and their fractions, whether or not refined, but not chemically modified |
| | | 2166 | Maize (corn) oil and its fractions, not chemically modified |
| | | 2167 | Palm, coconut, palm kernel, babassu and linseed oil and their fractions, refined but not chemically modified; castor, tung and jojoba oil and fixed vegetable fats and oils (except maize oil) and their fractions n.e.c., whether or not refined, but not chemically modified |

| Table A1. GSC2 Sectors defined by Reference to the Provisional CPC (Continued) | | | |
|---|---|---|---|
| GSC2 Number | Code | CPC Code | Description |
| 21 | vol | 2168<br>2169<br><br><br>217<br>218 | Margarine and similar preparations<br>Animal or vegetable fats and oils and their fractions, partly or wholly hydrogenated, inter-esterified, re-esterified or elaidinised, whether or not refined, but not further prepared<br>Cotton linters<br>Oil-cake and other solid residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes |
| 22 | mil | 22 | Dairy products |
| 23 | pcr | 2316 | Rice, semi- or wholly milled |
| 24 | sgr | 235 | Sugar |
| 25 | ofd | 212<br>213<br>214<br>215<br>2311<br>2312<br>2313<br>2314<br>2315<br>2317<br>2318<br>232<br>233<br>234<br>236<br>237<br>239 | Prepared and preserved fish<br>Prepared and preserved vegetables<br>Fruit juices and vegetable juices<br>Prepared and preserved fruit and nuts<br>Wheat or meslin flour<br>Cereal flours other than of wheat or meslin<br>Groats, meal and pellets of wheat<br>Cereal groats, meal and pellets n.e.c.<br>Other cereal grain products (including corn flakes)<br>Other vegetable flours and meals<br>Mixes and doughs for the preparation of bakers' wares<br>Starches and starch products; sugars and sugar syrups n.e.c.<br>Preparations used in animal feeding<br>Bakery products<br>Cocoa, chocolate and sugar confectionery<br>Macaroni, noodles, couscous and similar farinaceous products<br>Food products n.e.c. |
| 26 | b_t | 24<br>25 | Beverages<br>Tobacco products |

n.e.c. Not elsewhere classified

| Table A2. GSC2 Sectors defined by Reference to the ISIC, Rev. 3 | | | |
|---|---|---|---|
| GSC2 Number | Code | ISIC3 Code | Description |
| 14 | fsh | 015 | Hunting, trapping and game propagation including related service activities |
| | | 05 | Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing |
| 15 | col | 101 | Mining and agglomeration of hard coal |
| | | 102 | Mining and agglomeration of lignite |
| 16 | oil | 111 | Extraction of crude petroleum and natural gas (part) |
| | | 112 | Service activities incidental to oil and gas extraction excluding surveying (part) |
| | | 103 | Mining and agglomeration of peat |
| 17 | gas | 111 | Extraction of crude petroleum and natural gas (part) |
| | | 112 | Service activities incidental to oil and gas extraction excluding surveying (part) |
| 18 | omn | 12 | Mining of uranium and thorium ores |
| | | 13 | Mining of metal ores |
| | | 14 | Other mining and quarrying |
| 27 | tex | 17 | Manufacture of textiles |
| | | 243 | Manufacture of man-made fibres |
| 28 | wap | 18 | Manufacture of wearing apparel; dressing and dyeing of fur |
| 29 | lea | 19 | Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear |
| 30 | lum | 20 | Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials |
| 31 | ppp | 21 | Manufacture of paper and paper products |
| | | 2211 | Publishing of books, brochures, musical books and other publications |
| | | 2212 | Publishing of newspapers, journals and periodicals |
| | | 2213 | Publishing of recorded media |
| | | 2219 | Other publishing (photos, engravings, postcards, timetables, forms, posters, art reproductions, etc.) |
| | | 222 | Printing and service activities related to printing |
| | | 223 | Reproduction of recorded media |
| 32 | p_c | 231 | Manufacture of coke oven products |
| | | 232 | Manufacture of refined petroleum products |
| | | 233 | Processing of nuclear fuel |
| 33 | crp | 241 | Manufacture of basic chemicals |
| | | 242 | Manufacture of other chemical products |
| | | 25 | Manufacture of rubber and plastics products |
| 34 | nmm | 26 | Manufacture of other non-metallic mineral products |
| 35 | i_s | 271 | Manufacture of basic iron and steel |
| | | 2731 | Casting of iron and steel |

| Table A2. GSC2 Sectors defined by Reference to the ISIC, Rev. 3 (Continued) | | | |
|---|---|---|---|
| GSC2 Number | Code | ISIC3 Code | Description |
| 36 | nfm | 272 | Manufacture of basic precious and non-ferrous metals |
| | | 2732 | Casting of non-ferrous metals |
| 37 | fmp | 28 | Manufacture of fabricated metal products, except machinery and equipment |
| 38 | mvh | 34 | Manufacture of motor vehicles, trailers and semi-trailers |
| 39 | otn | 35 | Manufacture of other transport equipment |
| 40 | ele | 30 | Manufacture of office, accounting and computing machinery |
| | | 32 | Manufacture of radio, television and communication equipment and apparatus |
| 41 | ome | 29 | Manufacture of machinery and equipment n.e.c. |
| | | 31 | Manufacture of electrical machinery and apparatus n.e.c. |
| | | 33 | Manufacture of medical, precision and optical instruments, watches and clocks |
| 42 | omf | 36 | Manufacturing n.e.c. |
| | | 37 | Recycling |
| 43 | ely | 401 | Production, collection and distribution of electricity |
| 44 | gdt | 402 | Manufacture of gas; distribution of gaseous fuels through mains |
| | | 403 | Steam and hot water supply |
| 45 | wtr | 41 | Collection, purification and distribution of water |
| 46 | cns | 45 | Construction |
| 47 | trd | 50 | Sales, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel |
| | | 51 | Wholesale trade and commission trade, except of motor vehicles and motorcycles |
| | | 521 | Non-specialized retail trade in stores |
| | | 522 | Retail sale of food, beverages and tobacco in specialized stores |
| | | 523 | Other retail trade of new goods in specialized stores |
| | | 524 | Retail sale of second-hand goods in stores |
| | | 525 | Retail trade not in stores |
| | | 526 | Repair of personal and household goods |
| | | 55 | Hotels and restaurants |
| 48 | otp | 60 | Land transport; transport via pipelines |
| | | 63 | Supporting and auxiliary transport activities; activities of travel agencies |
| 49 | wtp | 61 | Water transport |
| 50 | atp | 62 | Air transport |
| 51 | cmn | 64 | Post and telecommunications |
| 52 | ofi | 65 | Financial intermediation, except insurance and pension funding |
| | | 67 | Activities auxiliary to financial intermediation |
| 53 | isr | 66 | Insurance and pension funding, except compulsory social security |
| | | | Contd |

| Table A2. GSC2 Sectors defined by Reference to the ISIC, Rev. 3 (Continued) | | | |
|---|---|---|---|
| GSC2 Number | Code | ISIC3 Code | Description |
| 54 | obs | 70 | Real estate activities |
| | | 711 | Renting of transport equipment |
| | | 712 | Renting of other machinery and equipment |
| | | 713 | Renting of personal and household goods n.e.c. |
| | | 72 | Computer and related activities |
| | | 73 | Research and development |
| | | 74 | Other business activities |
| 55 | ros | 92 | Recreational, cultural and sporting activities |
| | | 93 | Other service activities |
| | | 95 | Private households with employed persons |
| 56 | osg | 75 | Public administration and defence; compulsory social security |
| | | 80 | Education |
| | | 85 | Health and social work |
| | | 90 | Sewage and refuse disposal, sanitation and similar activities |
| | | 91 | Activities of membership organizations n.e.c. |
| | | 99 | Extra-territorial organizations and bodies |
| 57 | dwe | n.a. | n.a. |

n.a. Not available
n.e.c. Not elswhere classified

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## Appendix B. Regions in the GTAP 6 Data Base and Mapping to Standard Countries

| Number | Code | Name | Member Regions (226) | Code |
|---|---|---|---|---|
| 1 | AUS | Australia | Australia | AUS |
| 2 | NZL | New Zealand | New Zealand | NZL |
| 3 | XOC | Rest of Oceania | American Samoa | ASM |
| | | | Cook Islands | COK |
| | | | Fiji | FJI |
| | | | French Polynesia | PYF |
| | | | Guam | GUM |
| | | | Kiribati | KIR |
| | | | Marshall Islands | MHL |
| | | | Micronesia, Federated States of | FSM |
| | | | Nauru | NRU |
| | | | New Caledonia | NCL |
| | | | Norfolk Island | NFK |
| | | | Northern Mariana Islands | MNP |
| | | | Niue | NIU |
| | | | Palau | PLW |
| | | | Papua New Guinea | PNG |
| | | | Samoa | WSM |
| | | | Solomon Islands | SLB |
| | | | Tokelau | TKL |
| | | | Tonga | TON |
| | | | Tuvalu | TUV |
| | | | Vanuatu | VUT |
| | | | Wallis and Futuna | WLF |
| 4 | CHN | China | China | CHN |
| 5 | HKG | Hong Kong | Hong Kong | HKG |
| 6 | JPN | Japan | Japan | JPN |
| 7 | KOR | Korea | Korea, Republic of | KOR |
| 8 | TWN | Taiwan | Taiwan | TWN |
| 9 | XEA | Rest of East Asia | Macau | MAC |
| | | | Mongolia | MNG |
| | | | Korea, Democratic People's Republic of | PRK |
| 10 | IDN | Indonesia | Indonesia | IDN |
| 11 | MYS | Malaysia | Malaysia | MYS |
| 12 | PHL | Philippines | Philippines | PHL |
| 13 | SGP | Singapore | Singapore | SGP |
| 14 | THA | Thailand | Thailand | THA |
| 15 | VNM | Viet Nam | Viet Nam | VNM |

| | | | | |
|---|---|---|---|---|
| 16 | XSE | Rest of Southeast Asia | Brunei Darussalam | BRN |
| | | | Cambodia | KHM |
| | | | Lao People’s Democratic Republic | LAO |
| | | | Myanmar | MMR |
| | | | Timor Leste | TLS |
| 17 | BGD | Bangladesh | Bangladesh | BGD |
| 18 | IND | India | India | IND |
| 19 | LKA | Sri Lanka | Sri Lanka | LKA |
| 20 | XSA | Rest of South Asia | Afghanistan | AFG |
| | | | Bhutan | BTN |
| | | | Maldives | MDV |
| | | | Nepal | NPL |
| | | | Pakistan | PAK |
| 21 | CAN | Canada | Canada | CAN |
| 22 | USA | United States of America | United States of America | USA |
| 23 | MEX | Mexico | Mexico | MEX |
| 24 | XNA | Rest of North America | Bermuda | BMU |
| | | | Greenland | GRL |
| | | | Saint Pierre and Miquelon | SPM |
| 25 | COL | Colombia | Colombia | COL |
| 26 | PER | Peru | Peru | PER |
| 27 | VEN | Venezuela | Venezuela | VEN |
| 28 | XAP | Rest of Andean Pact | Bolivia | BOL |
| | | | Ecuador | ECU |
| 29 | ARG | Argentina | Argentina | ARG |
| 30 | BRA | Brazil | Brazil | BRA |
| 31 | CHL | Chile | Chile | CHL |
| 32 | URY | Uruguay | Uruguay | URY |
| 33 | XSM | Rest of South America | Falkland Islands (Malvinas) | FLK |
| | | | French Guiana | GUF |
| | | | Guyana | GUY |
| | | | Paraguay | PRY |
| | | | Suriname | SUR |
| 34 | XCA | Central America | Belize | BLZ |
| | | | Costa Rica | CRI |
| | | | El Salvador | SLV |
| | | | Guatemala | GTM |
| | | | Honduras | HND |
| | | | Nicaragua | NIC |
| | | | Panama | PAN |
| 35 | XFA | Rest of Free Trade Area of the Americas | Antigua & Barbuda | ATG |

| | | | | |
|---|---|---|---|---|
| | | | Bahamas | BHS |
| | | | Barbados | BRB |
| | | | Dominica | DMA |
| | | | Dominican Republic | DOM |
| | | | Grenada | GRD |
| | | | Haiti | HTI |
| | | | Jamaica | JAM |
| | | | Puerto Rico | PRI |
| | | | Saint Kitts and Nevis | KNA |
| | | | Saint Lucia | LCA |
| | | | Saint Vincent and the Grenadines | VCT |
| | | | Trinidad and Tobago | TTO |
| | | | Virgin Islands, U.S. | VIR |
| 36 | XCB | Rest of the Caribbean | Anguilla | AIA |
| | | | Aruba | ABW |
| | | | Cayman Islands | CYM |
| | | | Cuba | CUB |
| | | | Guadeloupe | GLP |
| | | | Martinique | MTQ |
| | | | Montserrat | MSR |
| | | | Netherlands Antilles | ANT |
| | | | Turks and Caicos | TCA |
| | | | Virgin Islands, British | VGB |
| 37 | AUT | Austria | Austria | AUT |
| 38 | BEL | Belgium | Belgium | BEL |
| 39 | DNK | Denmark | Denmark | DNK |
| 40 | FIN | Finland | Finland | FIN |
| 41 | FRA | France | France | FRA |
| 42 | DEU | Germany | Germany | DEU |
| 43 | GBR | United Kingdom | United Kingdom | GBR |
| 44 | GRC | Greece | Greece | GRC |
| 45 | IRL | Ireland | Ireland | IRL |
| 46 | ITA | Italy | Italy | ITA |
| 47 | LUX | Luxembourg | Luxembourg | LUX |
| 48 | NLD | Netherlands | Netherlands | NLD |
| 49 | PRT | Portugal | Portugal | PRT |
| 50 | ESP | Spain | Spain | ESP |
| 51 | SWE | Sweden | Sweden | SWE |
| 52 | CHE | Switzerland | Switzerland | CHE |
| 53 | XEF | Rest of EFTA | Iceland | ISL |
| | | | Liechtenstein | LIE |
| | | | Norway | NOR |
| 54 | XER | Rest of Europe | Andorra | AND |

| | | | | |
|---|---|---|---|---|
| | | | Bosnia and Herzegovina | BIH |
| | | | Faroe Islands | FRO |
| | | | Gibraltar | GIB |
| | | | Macedonia, the former Yugoslav Republic of | MKD |
| | | | Monaco | MCO |
| | | | San Marino | SMR |
| | | | Serbia and Montenegro | SCG |
| 55 | ALB | Albania | Albania | ALB |
| 56 | BGR | Bulgaria | Bulgaria | BGR |
| 57 | HRV | Croatia | Croatia | HRV |
| 58 | CYP | Cyprus | Cyprus | CYP |
| 59 | CZE | Czech Republic | Czech Republic | CZE |
| 60 | HUN | Hungary | Hungary | HUN |
| 61 | MLT | Malta | Malta | MLT |
| 62 | POL | Poland | Poland | POL |
| 63 | ROM | Romania | Romania | ROM |
| 64 | SVK | Slovakia | Slovakia | SVK |
| 65 | SVN | Slovenia | Slovenia | SVN |
| 66 | EST | Estonia | Estonia | EST |
| 67 | LVA | Latvia | Latvia | LVA |
| 68 | LTU | Lithuania | Lithuania | LTU |
| 69 | RUS | Russian Federation | Russian Federation | RUS |
| 70 | XSU | Rest of Former Soviet Union | Armenia | ARM |
| | | | Azerbaijan | AZE |
| | | | Belarus | BLR |
| | | | Georgia | GEO |
| | | | Kazakhstan | KAZ |
| | | | Kyrgyzstan | KGZ |
| | | | Moldova, Republic of | MDA |
| | | | Tajikistan | TJK |
| | | | Turkmenistan | TKM |
| | | | Ukraine | UKR |
| | | | Uzbekistan | UZB |
| 71 | TUR | Turkey | Turkey | TUR |
| 72 | XME | Rest of Middle East | Bahrain | BHR |
| | | | Iran, Islamic Republic of | IRN |
| | | | Iraq | IRQ |
| | | | Israel | ISR |
| | | | Jordan | JOR |
| | | | Kuwait | KWT |
| | | | Lebanon | LBN |
| | | | Palestinian Territory, Occupied | PSE |

| | | | | |
|---|---|---|---|---|
| | | | Oman | OMN |
| | | | Qatar | QAT |
| | | | Saudi Arabia | SAU |
| | | | Syrian Arab Republic | SYR |
| | | | United Arab Emirates | ARE |
| | | | Yemen | YEM |
| 73 | MAR | Morocco | Morocco | MAR |
| 74 | TUN | Tunisia | Tunisia | TUN |
| 75 | XNF | Rest of North Africa | Algeria | DZA |
| | | | Egypt | EGY |
| | | | Libyan Arab Jamahiriya | LBY |
| 76 | BWA | Botswana | Botswana | BWA |
| 77 | ZAF | South Africa | South Africa | ZAF |
| 78 | XSC | Rest of South African Customs Union | Lesotho | LSO |
| | | | Namibia | NAM |
| | | | Swaziland | SWZ |
| 79 | MWI | Malawi | Malawi | MWI |
| 80 | MOZ | Mozambique | Mozambique | MOZ |
| 81 | TZA | Tanzania | Tanzania, United Republic of | TZA |
| 82 | ZMB | Zambia | Zambia | ZMB |
| 83 | ZWE | Zimbabwe | Zimbabwe | ZWE |
| 84 | XSD | Rest of Southern African Development Community | Angola | AGO |
| | | | Congo, the Democratic Republic of the | COD |
| | | | Mauritius | MUS |
| | | | Seychelles | SYC |
| 85 | MDG | Madagascar | Madagascar | MDG |
| 86 | UGA | Uganda | Uganda | UGA |
| 87 | XSS | Rest of Sub-Saharan Africa | Benin | BEN |
| | | | Burkina Faso | BFA |
| | | | Burundi | BDI |
| | | | Cameroon | CMR |
| | | | Cape Verde | CPV |
| | | | Central African Republic | CAF |
| | | | Chad | TCD |
| | | | Comoros | COM |
| | | | Congo | COG |
| | | | Cote d'Ivoire | CIV |
| | | | Djibouti | DJI |
| | | | Equatorial Guinea | GNQ |
| | | | Eritrea | ERI |
| | | | Ethiopia | ETH |

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|---|---|---|
| | Gabon | GAB |
| | Gambia | GMB |
| | Ghana | GHA |
| | Guinea | GIN |
| | Guinea-Bissau | GNB |
| | Kenya | KEN |
| | Liberia | LBR |
| | Mali | MLI |
| | Mauritania | MRT |
| | Mayotte | MYT |
| | Niger | NER |
| | Nigeria | NGA |
| | Reunion | REU |
| | Rwanda | RWA |
| | Saint Helena | SHN |
| | Sao Tome and Principe | STP |
| | Senegal | SEN |
| | Sierra Leone | SLE |
| | Somalia | SOM |
| | Sudan | SDN |
| | Togo | TGO |